Soils

GLOBE Inquiry Model: DRAFT OUTLINE SHOWING TIME AND SEQUENCE
Total Time 17.75 hours (2 days, including max. travel time)

Day 1: Content 6.75 hours, Total time: 8.25 hours
Day 2: Content 8.00 hours, Total time: 9.50 hours (due to 1.5hours for particle density)
Prep time: 1 day

Note: *This outline provides you with a framework for agenda planning for implementation of the GLOBE inquiry-based training model. We have provided a basic content outline as well as a timeframe for completion of all activities. Currently, we have plans to develop and distribute complete lesson plan packages for each protocol area by the end of the current calendar year.*

DAY 1:

I. **Why are Soils Important?** (15 min.) (indoors)
   a. Concepts
      i. The different functions of soils
      ii. Soil is a limited resource
      iii. The Soil Story
   b. Activities
      i. Brainstorming - participants generate responses
      ii. Apple Activity

II. **What do you know about Soils?** (30 min.)
   a. Concepts (Participants generate questions utilizing their prior knowledge)
      i. How do local soils form (common vocabulary)?
      ii. How do we describe soils (common vocabulary)
   b. Activities (choose one):
      i. Soils in My Backyard (indoor activity)
         - use either local soils or soils brought by participants
         - have participants describe their soils using common vocabulary
         - have participants describe where their soils came from
         - questions regarding what factors developed their soil in this way
         - comparisons between soil types and locations
      ii. Initial Site Observations (outdoor activity)
         - take participants outside (not a soils pit) to observe and discuss landscape
         - discuss aspects of the landscape that would affect the soils here and how
         - discuss what soils will look like here and why
         - ask participants one thing they'd like to know about this soil

- ask them where would they put a (tree, house, athletic field, park, pond, wildlife habitat, parking lot, outhouse, vegetable garden, golf course, tall building), and why?

III. **Introduction to Soil Characterization** (75 min.)

a. Concepts

i. Soil formation

a. Parent material (types and corresponding soil characteristics affected by PM)
- residual, colluvial, alluvial, marine, lacustrine, glacial, eolian, organic, volcanic, urban
- color, texture, structure, density, mineralogy

b. Climate
- affects the chemical, physical, and biological characteristics of the soil
- how would soils in the rain forest differ from soils in the desert or from the arctic

c. Biota (vegetation, microorganisms, animals, human factors)
- how would a soil with grassland vegetation differ from one with forest

d. Topography (elevation, slope, and landscape position)
- how would soils differ on different parts of the landscape
- how would soils on north facing slope differ from south facing slope

e. Time
- what sets (and resets) the clock – i.e. volcanic eruption
- concept of scales; what's considered a young soil and an old soil
- concept of time – not just years, but intensity of soil formation and weathering (physical and chemical) process (soils might be chronologically young, but highly developed if in tropical climate where weathering is intense)

ii. Soil terminology
- horizon (number and depth), structure, color, consistence, texture, carbonates, roots, rocks

b. Activities:

i. Pictures/slides of different types of soils

ii. Auger profile and soil samples on plate

iii. Introduce Soil Characterization Data Sheet (use as template to introduce terms)

iv. Questions:
- why do we care about (texture, color, structure etc.)?
- in what kind of climate would you expect to find carbonates
- any links between the characteristics and the soil forming factors

- what would you expect soils to look like at your site based on the 5 soil forming factors?

IV. Break (15 min.)

V. **Soil Characterization Protocol Field Work** (90 min.) (outdoors – at soils pit)
   a. Concepts
      i. Reinforce links between soil characterization and soil forming factors
   b. Activities:
      i. Divide the participants into two groups. Have one trainer in the pit working with one group on soil characterization of a profile and the other trainer working on auger profiling, bulk density sampling and site definition (including GPS). Then have each group switch and work with the other trainer on the other task.
      ii. Back in lab weigh bulk density samples and put in oven for drying

VI. **Lunch** (60 min.)

VII. **Just Passing Through** (45 min.) (indoors)
   a. Concepts
      i. Different properties (texture, structure, and bulk density) affect water and energy (heat) movement through soils
      ii. Buffering and filtering effects of soils (pH, alkalinity, TDS)
      iii. Introduction to modeling
         - discussion on what is a model and why we use models
         - how is JPT a model and if we wanted to run an experiment with JPT how would what would we modify
         - discuss modifying one variable and controlling all the others
         - how to make model more scientific, more realistic

VIII. **Soil Moisture and Temperature Protocols** (60 min.) (indoors and outdoors)
   a. Concepts
      i. Soil properties affect water and energy (heat) movement through soils
      ii. Soils are dynamic - soil water and temperature change (hourly or more often)
      iii. Links between phenology and soil temperature
      iv. How do moisture and temperature change across the landscape, under different land cover, at different soil depths?
   b. Activities
      i. Why are soil moisture and temperature important – participants brainstorm and generate responses
      ii. Use Just Passing Through to introduce Soil Moisture and Temperature Protocols (note current JPT needs additions to include topic of soil temperature and relationship between soil temperature and moisture)

iii. Do soil moisture and temperature protocols near Soil Pit and Atmosphere site
iv. Weigh bulk density and soil moisture samples and put in oven

IX. **Break** (15 min.)

X. **Data Entry** (90 min.) (computer lab)
   a. Concepts
      i. How to enter soils data into the GLOBE database
   b. Activities
      i. Get Ids
      ii. Data entry (both web-base and email data entry)
         - include site definition, horizon definition, and characterization data

DAY 2:

I. **Question and Answer Period** (15 min.)
   a. Assessment of comprehension of key concepts through group discussion
   b. Reflection/one minute evaluation on Day 1
   c. Respond to reflections

II. **Lab Analysis Part I: Physical Characteristics** (4.5 hours total) (in classroom)
   a. Soil Moisture (SM)(30 min.)
      i. Concepts
         1. Climate, vegetation, topography, and soil properties (texture, structure, bulk density, porosity, organic matter content, horizon thickness,…) affect soil moisture
         2. Saturation, field capacity, and permanent wilting point and relative contribution to these values by sand, silt, and clay
      ii. Activities
         1. Discussion of field observations and measurements with segue into lab procedure
         2. Have participants generate formula for soil moisture
         3. Have participants weigh samples and calculate soil moisture of their samples
         4. Discussion about site and current climate conditions and soil moisture contents
         5. Future scenarios (i.e. heavy rain, land use change) and effect on the soil moisture
         6. Draw a diagram with SM values on a transparency and discuss/analyze class data
            - trends, outliers, need for more replication, hypotheses

- add soil characterization to transparency and have participants discuss connection between data sets (use this transparency to add data from the other protocols)

b. Bulk Density (Bd) (60 min)
   i. Concepts
      1. Bulk density = mass of dry soil per unit of volume (dry soil mass/total volume)
      2. Any factor affecting pore space (texture, structure, organic matter, roots, rocks, and compaction) will affect bulk density
      3. Range of bulk density: .1 to 2.2 gm/cm3
      4. Bulk densities are generally higher at deeper depths in the profile
   ii. Activities
      1. Discussion of field observations and measurements with segue into lab procedure
      2. Have participants generate formula
      3. Have participants complete bulk density protocol and calculate BD of their samples
      4. Analysis of results with links to other soil properties
      5. Draw a diagram with SM values on a transparency and discuss/analyze class data
         - trends, outliers, need for more replication, hypotheses
         - connection between other data sets (SM and soil characterization)

c. Particle Density (Pd) (90 min.)
   i. Concepts
      1. Particle density = mass per unit volume of soil particles (dry soil mass/solids volume)
      2. Particle density is not related to pore space; chemical composition and mineralogy determines particle density
      3. Particle densities for most mineral soils vary between 2.6 to 2.75 gm/cm3
      4. Porosity = 1- (Bd/Pd) x 100
   ii. Activities
      1. Have participants complete particle density and calculate PD of their samples
      2. Have participants generate formula for porosity
         - Volume of pores (Vp) = volume of air (Va) + volume of water (Vw)
         - Total soil volume (Vt) = Vp + Vs (volume of solids)
         - Therefore VP can also be written as: Vp = Vt-Vs
         - Porosity (P) in terms of a percentage: P = (Vt – Vs)/Vt
           Or: P = 1 – Vs/Vt
         - Pd = Ws/Vs therefore Vs = Ws/Pd
         - Bd = Ws/Vt therefore Vt = Ws/Bd

- P can also be written as: P = 1- (Ws/Pd)/(Ws/Bd)
- Which works out to: P = 1-Bd/Pd

3. relate soil moisture content to porosity (see protocol)

d. Particle size distribution (PSD) (90 min.)
   i. Concepts
      1. Particle size distribution helps us understand how much water, heat and nutrients the soil will hold and how fast these will move through soil
      2. Determined by a settling measurement using a hydrometer
      3. Stokes Law: a particle will settle as a function of its diameter and the properties of liquid in which it is settling (larger particles i.e. sand settle faster)
   ii. Activities
      1. List the equipment used for PSD (hydrometer, thermometer, 500-mL graduated cylinder, 50 g dry sieved soil, etc.) and give class a few minutes to come up with a protocol on their own to measure particle size distribution using this equipment
      2. Have participants complete particle size distribution protocol
      3. Have participants complete "Making Sense of the Particle Size Distribution Measurement" learning activity

III. **Lunch** (60 min.)

IV. **Lab Analysis Part II: Chemical Analysis** (90 min. total) (classroom/lab)
   a. Soil pH (45 min.)
      i. Concepts
         1. Soil pH is an indication of the soil's chemistry and fertility
         2. Climate, vegetation, parent material, soil properties, and human modifications (liming, pollution) affect soil pH
         3. Range from 2 to 11 with 5.5 – 7.5 optimal for agricultural production
         4. Soil pH affects the availability of plant nutrients (esp. P, usually need neutral pH)
      ii. Activities
         1. Complete soil pH protocol
         2. Analyze results connecting them to other soil properties
         3. Write class pH results on the same transparency diagram and discuss/analyze data
            - trends, outliers, need for more replication, hypotheses, connections between data
   b. Soil fertility (45 min.)
      i. Concepts
         1. Organic matter, clay content, parent material, land use, and climate affect soil fertility

2. Nitrogen, phosphorous, and potassium are the three primary nutrients needed for plant growth
3. Nitrogen cycle - a dynamic process that continually changes form (nitrate, ammonium, ammonia, nitrite) and amounts in soil (not stored in soil because usually in negatively charged form)
4. Phosphorous very immobile in soils; availability affected by soil pH – not available to plant at low (below 4) and high (above 7.5) pHs
5. Potassium availability affected by number of negative charges on the clay particles, gives indication of mineralogy

ii. Activities
1. Complete soil fertility protocol
2. Write class fertility results on the same transparency diagram used earlier for Bd and pH and discuss/analyze data.
- trends, outliers, need for more replication, hypotheses, and connections between data

V. **Data Entry** (60 min.) (computer room)
a. Activities (depending on facilities)
i. HIGH TECH - Enter and email the data via web/email after the collection
ii. LOW TECH - Fill out the data entry sheets and go over email data entry.

VI. **Telling the Soil Story** (30 min.)
a. Concepts
i. Link field observations and measurements to physical and chemical lab measurements
b. Activities
i. Final discussion of the complete data set here with transparency diagram generated from previous units. Emphasize connections between data sets.
ii. Tell soil story of site and discuss what makes and doesn't make sense of the data
iii. Solicit feed back on training from participants; what worked what didn't work, what concepts need to be reinforced

VII. **Wrap Up and Evaluations** (15 min.)
a. Wrap-up points
i. Websites - demonstrate Soil Science Education Web page *ltpwww.gsfc.nasa.gov/globe/index.htm*
ii. Important points of contact/local resources (e.g. USDA NRCS, Universities, etc.)

iii. Discuss student research possibilities
iv. Course evaluations